SATELLITE IMAGE MAPS OF WARSAW IN SCALES FROM 1: 50 000 TO 1: 10 000

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ABSTRACT

The image map of a big town is the new cartographic product of potential use in numerous applications including such as acquiring real estate of the town, general planning purposes, management on the district level and engineering associated with construction setting and for digital topographic map revision up to the scale 1: 25,000. New generation of satellite maps of Warsaw area in scales from 1: 50,000 to 1: 10,000 elaborated fully digitally at the Institute of Geodesy and Cartography are presented.
The raw data used were: KFA-1000 and KVR-1000 Russian high resolution space photographs in scale approx. 1: 220,000, SPOT XS digital data and topographic maps in scales 1: 10,000, 1: 25,000, 1: 50,000.
The methodology of elaborating six different kinds of the satellite maps using digital image processing systems VI²STA of the I²S and ISI-3 Intergraph is discussed. Several new concepts of the design of the image map are presented including different use of colours and the application of topographic signs. High resolution of the KVR-1000 image is shown on the example of the 1: 10,000 scale Black/White image map. Two approaches to the use of colours in the image map are shown in scales 1: 25,000 and 1: 50,000. One is the "traditional" remote sensing reach palette with all greens in red and the other is semi - natural set of colours limited to 3 or 4 but with changing intensities to imitate the traditional map colours. The idea of making the image map easy to use is realised through overlying the image by the classic topographic map symbology.
Final hard-copies printed on IRIS, STORK and BARCO Ink-Jet printers will be presented.
The planimetric accuracy RMSE x,y = ± 7.8 m was achieved for the 1: 25,000 scale map which corresponds to 0.3 mm as measured on the map sheet.
This digital image maps are useful also for updating topographic maps up to the scale 1: 25,000.

1. B/W AND FALSE COLOUR KFA-1000 RUSSIAN SATELLITE PHOTOGRAPHS.

KFA-1000 photographs have been used in the Institute of Geodesy and Cartography (IGiK) for topographic map updating up to the scale 1: 50,000 since 1985. These photographs have been also used for elaborating orthophotomaps in the scale 1: 50,000 using analytical plotter Planicomp P-1 and Orthocomp Z-1 ZEISS. Results were presented and published on the XVI ISPRS Congress in Kyoto (Kaczyński and Konieczny 1988).
KFA-1000 are tilted ± 8 degrees or ± 20 degrees and have stereoscopic overlap 60%. Ground resolution about 6 m.
Image coordinates measured on the KFA-1000 images have to be corrected for big radial distortion characteristic for the lens of the space camera and for the deformation of the Russian spectrozonal film.
This KFA-1000 have been scanned on the P-1700 Optronics with aperture size 25 µm. First satellite B/W image map of Warsaw in scale 1: 50,000 has been elaborated fully digitally in IGiK on the ERDAS V.7.3 software. Hard copy were printed on the STORK Evidence high precision Ink-Jet printer by the GEOSYSTEMS GmbH in 1993.

Software for space triangulation using KFA photographs has also been developed in IGiK. A block consisting of the three strips (each containing six space photographs with 60% overlap and 10% sidelap) was elaborated using only 6 GCP's. Using check points RMSE x,y = ± 7 m and RMSE z = ± 30 m were achieved. These photographs and calculated coordinates of the photopoints have been used for production of orthophotomaps and updating of topographic maps up to the scale 1: 50,000. As the base/height ratio of the KFA-1000 (b/h = 1/8.3) is rather poor, high accuracy of DEM is not possible to achieve. Nevertheless, DEM elaborated analytically or digitally with accuracy approx. 30 m could be generated.

2. HIGH RESOLUTION KVR-1000 SATELLITE PHOTOGRAPHS.

The KVR-1000 photographs are a new generation of the Russian space data (available to civilian application only for the last two years). Black and White or false colour photographs are taken by a panoramic camera with 1000 mm focal length, from unmanned satellites. Only the central part of the photograph (size 18 by 18 cm) is extracted and digitised usually with 7.5 µm and 15 µm apertures. General

description of the camera and some results of elaborating of these photographs for mapping up to the scale 1: 10,000 have been reported by Sollner (1993), Marek (1995), Kaczyński (1994), Muller *et al.* (1994), Konecny (1995).

Depending on the contrast, the ground resolution of these data varies from 1.2 to 4 m.

KVR-1000 photograph of Warsaw area was scanned with pixel sizes 15 µm and 25 µm. Some noise was filtered out in the Fourier domain on the I²S VI²STA system. Enhancement of edges has been done using Raise-Power and high-pass Gauss and Exponential filters in the frequency domain.

This filtered, enhanced image was used for elaborating a few satellite image maps of Warsaw. Since the area of Warsaw is flat, the DEM was not used for rectification.

The image was rectified with accuracy less than 0.5 pixel to military topomaps in the scale of 1: 25,000 using 180 well identified and distributed control points.

SPOT XS digital data was registered to the rectified digital KVR-1000 image.

A first order polynomial transform and bilinear interpolation resampling method was used to create new SPOT XS data with pixel size recalculated from 20 m by 20 m to 5.8 m by 5.8 m pixel size. Image to image registration has been checked on I²S VI²STA using correlation software (RMSE < 0.5 pixel, r = 0.97). As two bands of SPOT multispectral data were correlated XS1 and XS2 bands were added with weighted coefficient.

After applying different contrast enhancement a few colour composites were prepared. One of this was: XS3 was coded with a Red filter, KVR-1000 with Green and XS1 + XS2 with Blue.

The first false colour satellite image map of Warsaw in scale of 1: 25,000 was printed on the STORK Evidence Ink-Jet printer by Geosystems GmbH in 1993.

This satellite image map was checked against topomaps in the scale of 1: 25,000 on 80 well identified points. Final RMSE x = 6 m, RMSE y = 5 m was achieved, which corresponds to RMSE x,y < 0.3 mm in the final map scale. This map has been elaborated in cooperation with the SURFACES Laboratory of the University in Liege.

Another version of the satellite image map in the scale 1: 25,000 was produced also digitally in IGiK on the ISI-3 Intergraph and printed on a Rolland offset device by EUROSENSE in 1994.

The third "satellite topoimage map" has been generated also digitally in the scale 1: 25,000. The black topographic layer was scanned from military topographic maps in the 1942 cartographic coordinates system in the scale 1: 50,000 on the Intergraph large format scanner ANATech 3640 with an aperture of 800 DPI in order to create raster map files. After merging together a few topomaps a new digital map was resampled to 5.8 m by 5.8 m pixel size using nearest neighbour method. Boolean algebra was used for super-imposition of the satellite image map with the digital topomaps. The result was a new satellite image map in the scale of 1: 25,000 printed with the topographic information as white overlay on a BARCO Ink-Jet printer. This digital map was used for updating of the old 1983 topographic map. The results were presented at the ISPRS Symposium, Working Group IV/3 held in Athens, Georgia, USA in 1994 (Muller *at el.* 1994).

Part of this colour satellite topoimage map of Warsaw reduced to the scale of 1: 40,000 as B/W image is shown on Fig.1. Topographic features are shown in white superimosed on merged KVR-1000 with SPOT XS images.

KVR-1000 scanned on the PS-1 ZEISS/INTERGRAPH with the aperture 15 µm was used for elaborating new colour satellite image maps of Warsaw in scales of 1: 50,000, 1: 25,000 and B/W in scale of 1: 10,000.

This green - beige - blue satellite image map in scale 1: 50,000 is also based on KVR-1000 B/W photograph as the other versions. Its colour conception was realised by Dr. J. Drachal from IGiK as follows. The areas of vegetation e.g. parks, recreation grounds, woods and gardens have been classified on SPOT XS imagery and transferred to higher resolution Kosmos image after warping and resampling. They are represented in green colour. Blue colour shows the hydrography of the area. The areas of all bodies of water have been interpreted on the KVR-1000 image with the aid of the topographic map and vectorized on the screen using MicroStation software. The rest of the map area was coloured beige only with main streets underlined reddish.

The separation of only two classes of objects shown in colours different from the beige background makes this map easy in perception despite quiet form. This is because colours are not the only mean of distinction of objects and there are also different shades, textures and the sharp drawing of a high resolution photograph itself which convey the information.

Several surfacial objects can be easily distinguished by its colour and texture as shown in boxes of the legend.

The map is also elaborated in the Gauss - Krüger 6 degrees projection in coordinate system 1942. The two patches in corners show the Old Town and the centre of the city in scale 1: 10,000.

The map has been elaborated on ISI-3 Intergraph and printed on the IRIS 3047 Ink-Jet printer in IGiK in 1996.

The another satellite image map in scale 1: 25,000 is also based on KVR-1000 B/W photograph and the topographic maps in scale of 1: 10,000 used as a source of colour distinction of topographic objects. Built-up areas have been extracted from topographic maps and shown on a satellite map in red colour.

The satellite B/W image map in scale 1: 10,000 was also elaborated on the VI²STA of the I²S system in IGiK.

Accuracy of this map is RMSE x,y = ± 3 m.

Hard copy of the map was printed on the IRIS 3047 Ink-Jet printer in IGiK in 1994.

Usefulness of KVR-1000 image for updating of the topographic maps are shown on Fig.2 and Fig.3. The old topographic map in scale 1: 25,000 has been updated digitally using MicroStation software.

Fig.1. Part of a satellite topoimage map of Warsaw reduced to the scale of 1: 40,000.

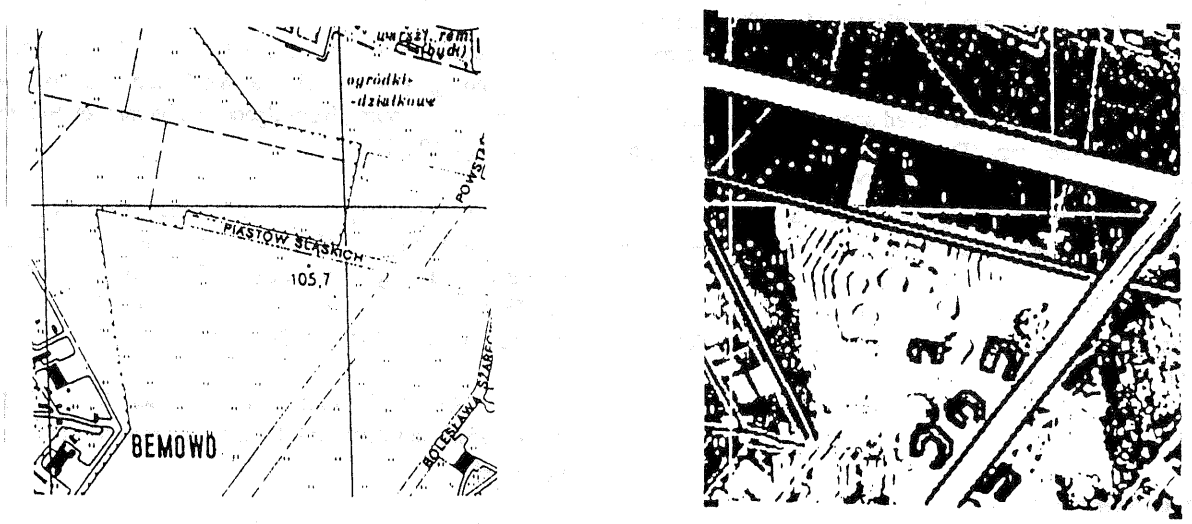

Fig.2. New buildings and runway in the old Bemowo airport: Left: old topographic map; Right: KVR-1000 image with updated runway and new housings.

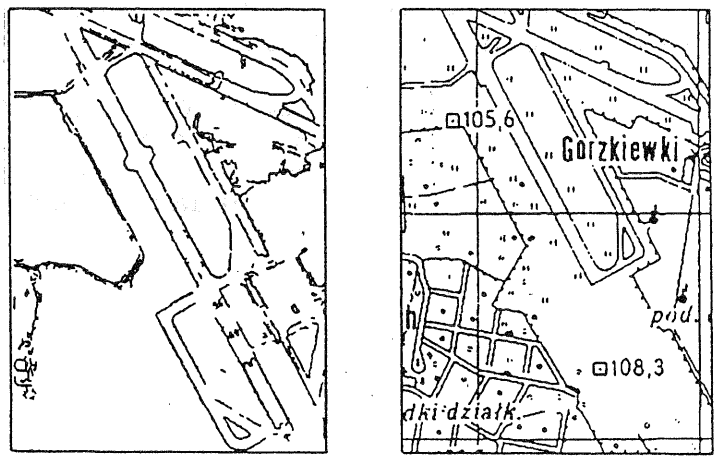

Fig.3. New runway on the Warsaw International Airport and old topomap: Left: runway extracted from the KVR-1000 image using edge enhancement, thresholding and linear features preservation filter operations on VI²STA I²S.
Right: old topomap 1983

3. CONCLUSIONS.

Russian KVR-1000 high resolution space photographs and SPOT XS digital data have been successfully used for generating satellite image maps and satellite topoimage maps up to the scale of 1: 25,000 with acceptable accuracy.
The following different professional software and hardware were used in this project: System 600 Model 75 and VI²STA of the International Imaging Systems, ImageStation Imager ISI-3 of the Intergraph, ERDAS Imagine Map Composer, P-1700 Photomation Optronics film scanner/writer device and PS-1 PhotoScan ZEISS/INTERGRAPH, Intergraph ANATech 3640 large format scanner, STORK, BARCO and IRIS Ink-Jet printers.
SPOT XS data with pixel size 20 m by 20 m was found good enough for merging with the high spatial resolution KVR-1000 panchromatic photograph. SPOT multispectral data have added false colours to the satellite image maps.
Black and White satellite image maps in the scale 1: 10,000 could be generated using KVR-1000 scanned with aperture 15 µm. However, the accuracy will not meet the standards for this scale. In this case coordinates of GCP's should be taken from existing aerial triangulation or measured directly in field by GPS techniques.
KVR-1000 images have been used successfully by IGiK and SURFACES Laboratory (Donnay, 1994) for updating topographic maps up to the scale 1: 25,000.
Colour hard copy image maps of Warsaw and Liege in scale 1: 25,000 were also printed with the use of the offset technique.
These image maps were also very beneficial to the Warsaw area in its urban planning and monitoring change detection activities.

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